Management of black Locust (*Robinia pseudoacacia* L.) stands in Hungary

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Abstract: Black locust (*Robinia pseudoacacia* L.) was the first forest tree species to be imported from North America to Europe at the beginning of the 17th century. It is the most important fast-growing stand-forming tree species in Hungary. Black locust plantations can be successfully established in response to a range of economic and ecological opportunities. Plantation survival and productivity are maximized by matching the species' growth characteristics with silvicultural options and land management needs. In the paper the sequence of forest tending operations in black locust stands is proposed, based on results of long-term stand structure and forest yield trials. Implementing good silvicultural plans and models will lead to profitable black locust stands and greater acceptance of the species by land managers. Black locust would also be a very useful species for energy productions as the related research results have been shown in the paper.

Keywords: Black locust (*Robinia pseudoacacia* L.); Management, Yield

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Introduction

In Hungary, black locust (*Robinia pseudoacacia* L) forest occupied 37.000 hm^2 in 1885, 109.000 hm^2 in 1911, 186.000 hm^2 in 1938 and 350.000 hm^2 in 2001. Approximately 20 % of all forested area in Hungary is covered by black locust. One-third of these stands are high forest and two-thirds of them are of coppice origin. In the 1960s, Hungary had more black locust forests than all the other European countries combined.

Black locust forests in Hungary have been established on good as well as medium and poor quality sites. Establishment of timber stands of good quality is possible only on sites with adequate moisture and well-aerated and loose structured soil, rich in nutrients and humus. Black locust forests on medium and poor quality sites are utilized for the production of fuelwood, fodder, poles and props, as well as production of honey, soil protection and environmental improvements.

The rapid spread of black locust was promoted both in the past and at present by the following factors:

- The need to fix loose shifting sands;
- Demands for afforestation of abandoned agricultural lands;
- Abundant seed yield, vitality, excellent ability for Sprouting and ability to fix free atmospheric nitrogen;
- Wide range of uses for its wood (tool manufacture, fuel wood, vineyard poles and props, pit-wood);
- Bee forage from its flowers.

The importance of black locust will probably increase in the future due to the multiple possibilities for the utilization of its wood and the favourable impact of the black locust afforestation on the environment (Führer 1998).

Management of black locust stands

Stand establishment (initial spacing)

Climate, hydrology and genetic soil types are the factors that determine the site type, and this in turn determines the choice of tree species. Water regime of soil is also highly influenced by the texture of soil, whether it is detritus, coarse sand, loam or clay. Black locust – because of its high requirement for both water and aeration in the soil – cannot be grown on soils composed of detritus, coarse sand or clay if the rootable depth is very shallow.

Black locust requires well-drained soils with adequate moisture if the associated nitrogen-fixing rhizobium bacteria are to thrive. That is why soil preparation (total or partial) to improve aeration and the water regime of the soil and interrow cultivation are necessary.

Black locust afforestations and artificial regenerations can be established with seedlings. The most popular planting spacing for black locust in Hungary is 2.4 m by 0.7 to 1.0 m, requiring at least 4000 seedlings/hm^2.

The right choice of initial spacing is one of the most important items of a plantation-like timber-growing technology (Veperdi G. 1988, Halupa, Gabnai 1990). Yet, we have not obtained much reliable information on the impact of initial spacing on stand structure and yield of young black locust stands. The reason is a small number of relevant experiments. Timber-growing developments are aiming partly the tightening of the 2.4 m x 0.7–0.8 m spacing used in the

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practical forestry or partly the use of wide spacing usual in hybrid poplar plantations. The following aspects must be considered in choosing the initial spacing.

The narrow spacing:

- provides more gross initial timber volume,
- the natural pruning of stem is promoted, crown closure comes in a rather short time,
- the danger of weed growth is less intensive,
- chances for spontaneous selection of stems are better, but the diameter growth is less,
- the subsequent silvicultural operations are more expensive and the selling price of timber is less profitable,
- some operations, like soil cultivation can be mechanized with difficulties.

The wide spacing:

- provides less timber yield at the beginning,
- branch development is more intensive, crown closure is slower,
- weed growth is more aggressive,
- mean diameter is thicker and the rotation age can be somewhat reduced,
- financial charge of forest tending operations is lower and the timber volume produced can be sold at a more profitable price,
- some operations can be better mechanized.

According to our research results obtained from spacing trials the seedling-number of afforestation with black locust may not be more than 4500–5000 pieces per hectare. This stem number means a growing space of approximately 2.0–2.2 m per individual, which can be attained by a row distance of 2.4 m and 0.8–1.0 m in-row-spacing. With this number recommended above an equal stem dispersion and timely closure can be created for the successful accomplishment of afforestation-phase (up to the age of 4) without compromising the mortality-rate.

Based on the investigations of this topic the desirable stem number at the accomplishment of clearing phase is 1 700–1 800 individuals per hectare in black locust stands of III–IV yield class. According to the latest experiences, if the row distance is reduced by 1.8 m and the in-row-spacing increased to 1.2 m, the individual development is more favourable (Rédei 2001).

Black locust stands can be regenerated *by coppice* (from root suckers), as well. In young stands of coppice origin, a cleaning operation should be carried out to adjust spacing when the stands are 3–6 years old and should reduce stocking to less than 5 000 stems/hm^2.

Tending operations in black locust stands

The black locust is a fast-growing tree species, which, up to the age of 10–15 years, is able to quickly close canopy openings caused by tending operations, but the closure is much slower in later years. Height growth peaks within the first five years, while diameter growth peaks in the first decade. The peak of current annual increment is at about age 20, whereas that of the mean annual increment is at about age 35–40.

To find the right cleaning and thinning intensity, the so-called growing space index is a good method. This index expresses the mean distance between trees (in a triangular pattern) as a percentage of mean height after cleanings and thinnings. The mean value of the index for black locust stands should be 23–24 %. Pruning of crop trees should also be carried out. After finishing selective thinning, stems must be free of branches up to a height of 4–6 m.

The objective of tending is to produce a high proportion of good quality sawlogs from stands of yield class I and II; some sawlogs and a high proportion of poles and props from stands of yield class III and IV; and poles, props and other small-dimension industrial wood from other yield stands.

A forest-tending model shown in Table 1 demonstrates the most important structure and yield parameters of the residual stand for high and coppices black locust stands by six yield-classes (Rédei 1997). Mean tree height is the most important model factor because it determines the timing of the tending operations. If the stem number (density) does not exceed the one that is prescribed in the table, no thinning is needed.

Yield, harvest cutting and wood utilization

On Figure 1 the most important stand structure and yield factors of black locust main crop (height, DBH, volume, total volume, mean annual increment of total volume) can be seen.

According to our yield table the volume of main crop varies between 80 and 280 m^3/hm^2 in function of yield classes at the age of 30 years, which is the average rotation age for black locust stands in Hungary. The black locust stands of Yield Class I–II have a rotation of 35–40 years and an annual increment of total volume of 12–14 $m^3 \cdot hm^{-2} \cdot a^{-1}$. The stands of Yield Class III–IV have a rotation of 30 years and an annual increment of 8–9 $m^3 \cdot hm^{-2} \cdot a^{-1}$. Finally, the poorest stands (Yield Class V–VI) have a rotation of 20–25 years and an annual increment of 4–6 $m^3 \cdot hm^{-2} \cdot a^{-1}$. In first generation coppice stands, growing stock, increment and health are similar to those in high forests.

Current utilization of black locust timber can be divided into three categories to reflect the changes that have occurred.

Category I *Traditional products:* firewood, sawn timber, pit-props, parquet, railway sleepers, vineyard poles and props, sawn and roundwood framing in agricultural building, fence-posts, etc..

Category II *Relatively new products* (produced on a large-scale mainly in the last decade and increasingly in the future, depending on market conditions) include barrel staves and barrels for wine, structural wood for construction purposes (e.g. glue-laminated structures, agricultural building frames made of round timber), furniture moulding, furniture components, particle board, fibreboard and pallets.

Category III *New products* (which may be soon manufactured on a large-scale) include glue-laminated railroad switch sleepers, bridge components and case components.

Table 1. Tending regimes for high and coppice common black locust stands (Yield model: Rédei 1997)

Operation	Age (year)	Height /m	Basal area /m^2/hm^2	DBH /cm	Density /stems/hm^2	GS* /m^2	Volume cut /m^3/hm^2
			Yield Class I				
Cleaning	5	8	7	6	2500	2.1	6
Cleaning	9	13	13	10	1700	2.6	20
Selective thinning	12	16	12	13	900	3.6	30
Selective thinning	18	20	17	19	600	4.4	35
Increment thinning	25	24	18	24	400	5.4	50
Harvest cutting	40	27	32	32	400	5.4	425
			Yield Class II				
Cleaning	6	8	7	6	2500	2.1	5
Cleaning	10	12	13	10	1700	2.6	20
Selective thinning	15	16	14	14	900	3.6	35
Increment thinning	22	20	17	20	550	4.6	45
Harvest cutting	35–40	23	29	26	550	4.6	340
			Yield Class III				
Cleaning	7	8	7	6	2700	2.5	4
Cleaning	12	12	14	10	1800	2.5	15
Selective thinning	17	15	16	14	1100	3.3	35
Increment thinning	22	18	17	17	700	4.1	40
Harvest cutting	30	20	26	22	700	4.1	270
			Yield Class IV				
Cleaning	8	8	8	6	3000	1.8	4
Cleaning	13	11	15	10	2000	2.4	15
Selective thinning	19	14	13	13	1000	3.4	35
Harvest cutting	30	17	25	18	1000	3.4	235
			Yield Class V				
Cleaning	9	7	7	5.5	3000	1.8	4
Cleaning	15	10	9	9	1500	2.8	20
Harvest cutting	25	14	20	13	1500	2.8	155
			Yield Class VI				
Cleaning	10	6	7	5	3500	1.6	-
Cleaning	(15)	(8)	(8)	(7)	(2000)	(2.4)	(15)
Harvest cutting	(20)	(10)	(12)	(9)	(2000)	(2.4)	(70)

Note: GS—means "growing space"

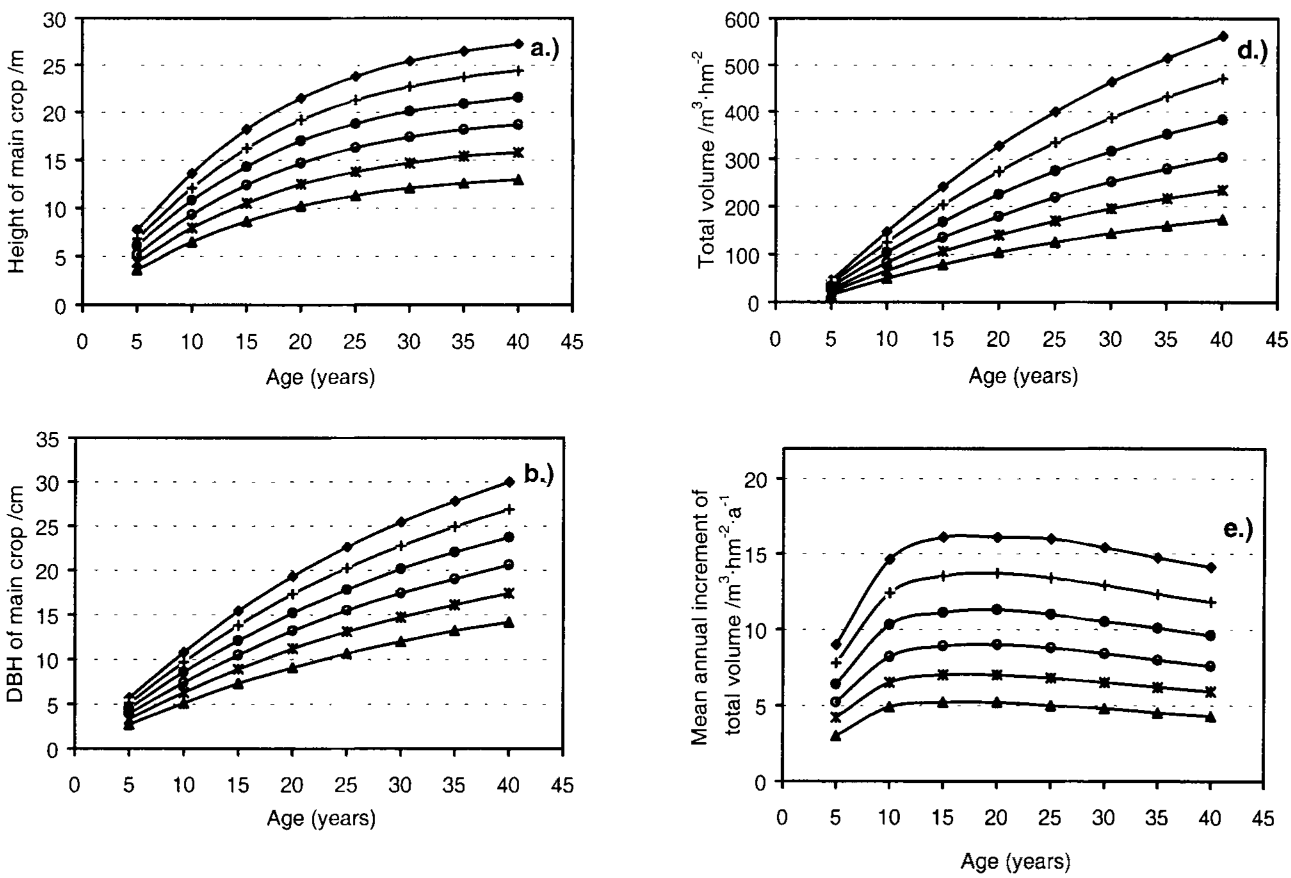
Management and yield of black locust energy plantations

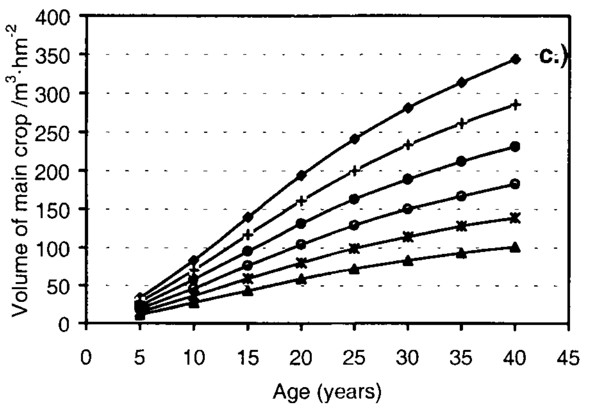
More and more agricultural land is being taken out of use for food crops, some of which can be used for wood energy production plantations. Black locust is the very best tree species for this purpose, since it has excellent energy production properties, such as:

- vigorous growing potential in juvenile phase,
- excellent coppicing ability,
- high density of the wood,
- high dry matter production,
- favourable combustibility of the wood,
- relatively fast drying,
- easy harvesting and wood processing.

In the last decade several energy production plantations have been established in Hungary. In these experiments, several spacing treatments were tested and the common black locust as well as its cultivars were compared.

In Helvécia (central Hungary, sand-soil region) an energy plantation was established using common black locust and its cultivars. The various tree spacings of the common black locust were: 1.5x0.3 m, 1.5x0.5 m and 1.5x1.0 m. At the age of 5 years the closest spacing (1.5x0.3 m) produced the greatest annual increment in oven-dry mass (6.5 $t\cdot hm^{-2}\cdot a^{-1}$). This exceeded the increments of the two wider spacings by 33 % and 51 %, respectively. According to the results of the yield trial with black locust cultivars planted at 1.5x1.0 m spacing, at 5 years the highest yield was produced by the cultivars *'Üllői'* (8.0 $t\cdot hm^{-2}\cdot a^{-1}$), followed by *'Jászkiséri'* (7.3 $t\cdot hm^{-2}\cdot a^{-1}$) and the common black locust (6.7 t/ha/yr) (Fig. 2).





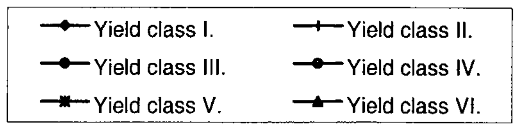


Fig. 1 a-e. Black locust stand structure factors in function of age (Graphic Yield table: Redei 1997)
a.) Height of main crop-age relationship; b.) DBH of main crop-age relationship; c.) Volume of main crop-age relationship; d.) Total volume-age relationship; e.) Mean annual increment of total volume-age relationship

Black locust energy forests can also be established by coppicing. Advantages of energy forests of coppice origin are that the cost of establishment is low compared to that of soil preparation, plantation and cultivation. From the developed root system of the previous stand, a large dendromass can be produced within a short time period. Disadvantages of these forests are that the area distribution of trees in coppice stands, is not as uniform as in plantations optimized for energy production. In coppice stands the quantity of the produced dendromass is lower and the length of growing time is highly influenced by the uneven stem distribution numbers of stems.

The first peak of the annual increment in volume of black locust energy forests established from sprouts falls between the age of 3 and 5 years. Then, the annual increment declines and a new peak occurs between age 9 and 12 years. A further maximum is expected later on, at about 15 years because of an even higher degree of mortality. Approximately one-third of the stems are lost at age 7 and 8. By the 12–13 years, the stem numbers decreased to less than 50 %.

The experiences from both the planted and the coppiced energy plantations and other stands indicate that it is not reasonable to harvest in the first three years, as the yield in oven-dry weight in the fifth year is 2–3 times greater than it is in the four year. Harvesting too early may also increase the population of biotic pests.

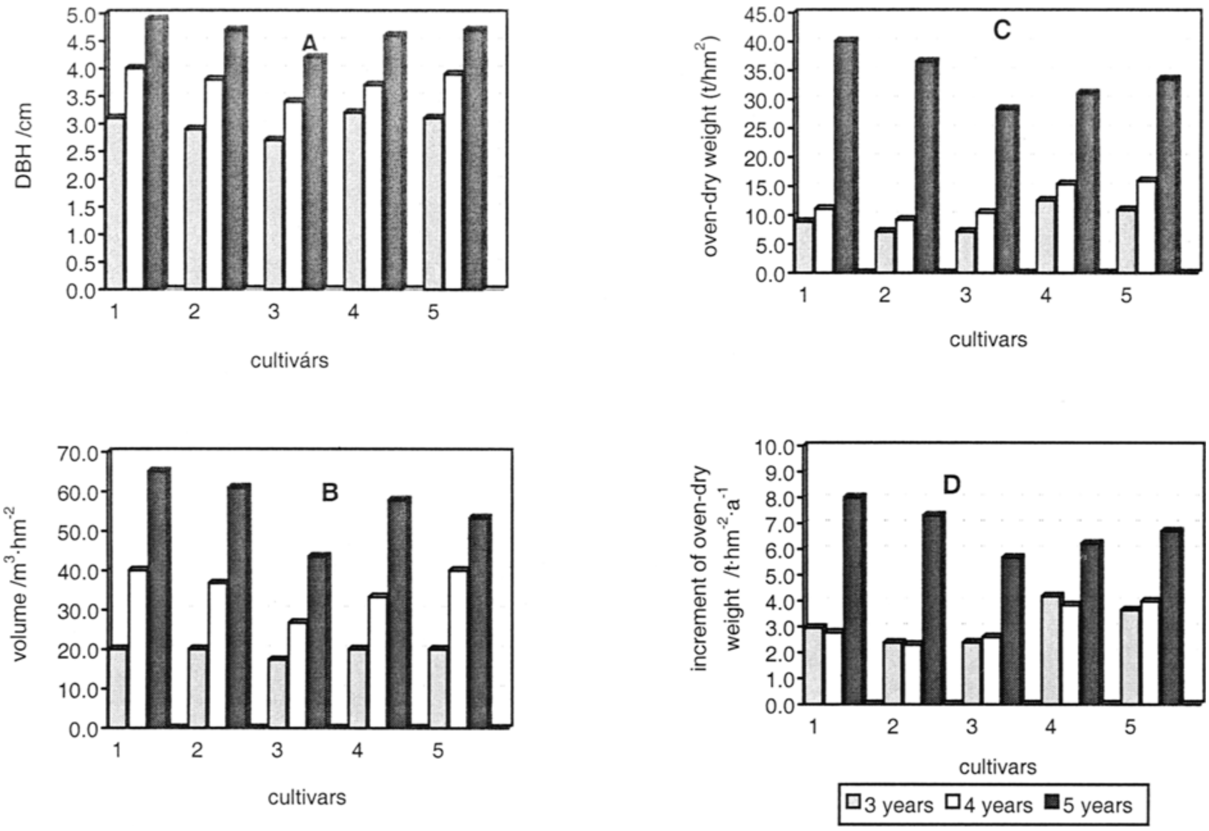


Fig. 2 A-D. DBH (A), Volume(B), oven-dry weight (C) and increment of oven-dry weight (D) of energy plantation established with black locust cultivars at 3, 4 and 5 years
Cultıvars: 1. Üllői, 2. Jaszkiseri, 3 Nyírségi, 4 Kiscsalai, 5. Common black locust

Conclusion

Black locust was the fırst forest tree species introduced from North America to Europe. Hungary has got much experience in black locust growing, as it has been grown for more than 200 years in the country. Being aware of black locust importance, forest research in Hungary has been engaged in resolving various problems of black locust management for a long time, and a lot of research results have already been implemented to the forestry practice.

In the future there are two bigger regions, where the fast spread of black locust can be expected. In Europe the Mediterranean countries (Italy, Greece, Spain and Turkey), while in Asia China and Korea may be the most prominent black locust growers.

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